Transportation, Energy, and the Environment

There are many complicated interactions among transportation, energy use, and environmental quality. This chapter highlights trends and events of the past year that reflect the importance of transportation to the nation's energy security and the quality of our environment. The year 1997 saw record-high oil imports, a dramatic international agreement to reduce emissions of greenhouse gases (GHGs), and an Environmental Protection Agency (EPA) decision to toughen federal air quality standards. These developments have major implications for the future of transportation in the United States and the world.

Most of the oil consumed in the United States goes to transportation. In 1997, transportation-driven oil demand together with declining domestic production brought about the highest levels of oil imports ever (48 percent of oil use). Yet, the question of oil dependence is far removed from the national consciousness. In the first part of this chapter, the importance of growing oil dependence in a world of plentiful and low-cost oil is examined.

The U.S. transportation system is about 95 percent petroleum dependent, down about two percentage points from a decade ago. While federal programs have boosted the numbers of alternative fuel vehicles in use in recent years, most of the increase in nonpetroleum energy has come via the blending of alcohols and ethers in gasoline.

The composition of gasoline sales has changed dramatically over the past 15 years, primarily as a result of environmental regulations.

In December 1997, in Kyoto, Japan, the nations of the world reached a historic agreement to limit GHG production resulting from human activities. Greenhouse gases in the Earth's atmosphere trap heat energy that would otherwise escape into space, thereby warming the Earth's climate. Many scientists contend that the continued addition of GHGs to the atmosphere, especially from the combustion of fossil fuels, threatens to alter the world's climate in potentially harmful ways (IPCC 1996). Emissions of GHGs from transportation, mainly produced when hydrocarbon fuels are burned and produce carbon dioxide (CO_2), continue to increase because of the steady growth of freight and passenger travel, the slowing of energy efficiency gains, and continued reliance on carbon-based fossil fuels.

Emissions of all criteria pollutants have decreased over the past two decades as a result of ever-improving vehicle emissions controls, despite the doubling of vehicle travel. These improvements have produced tangible benefits in the form of better air quality for U.S. cities. While transportation and the economy as a whole have made significant progress in curbing pollutant emissions, evidence continues to mount on the adverse health effects of air pollution, especially fine particulates and ozone. As a result, EPA has decided to impose stricter air quality standards on cities, with potentially significant implications for transportation vehicles and fuels.

Past air quality standards have had an overwhelmingly beneficial effect, according to a recent study of the costs and benefits of the first two decades of Clean Air Act (CAA) regulations (USEPA OAR 1997). Emissions of lead, hydrocarbons, carbon monoxide, oxides of nitrogen, and sulfur have all been significantly reduced.

Transportation's other environmental impacts include increased noise and solid waste, deterioration of water and groundwater quality, damage to habitats, and direct and indirect effects of land use. The lack of information with which to comprehensively assess the role of transportation in these environmental concerns remains a problem.

ENERGY USE

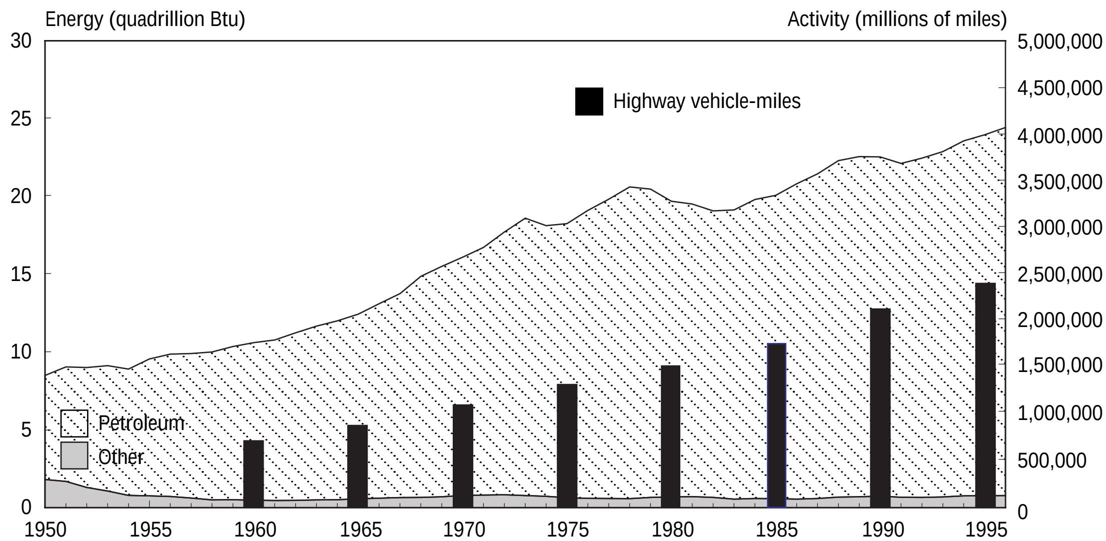
The energy needed to power the U.S. transportation system grew at almost the same rate as the economy in 1996: 2.3 percent versus 2.4 percent for Gross Domestic Product (GDP) (USDOE EIA 1997a, table 2.1). In general, however, passenger and freight transportation are growing faster than the economy as a whole. Highway vehicle-miles increased at an average rate of 3.2 percent per year between 1970 and 1996 (see figure 4-1). Highway vehicles continue to dominate transportation energy use (see figure 4-2). Light-duty passenger vehicles alone account for over 60 percent of all energy used in transportation.

The growth of transportation energy use reflects the combined effects of increased transportation activity and changes in energy efficiency. As described in chapter 1, passenger travel and freight activity continue to grow, resulting in more vehicle-miles traveled and airplane use. These trends show little sign of slowing down in the near future.

Transportation and Oil Dependence

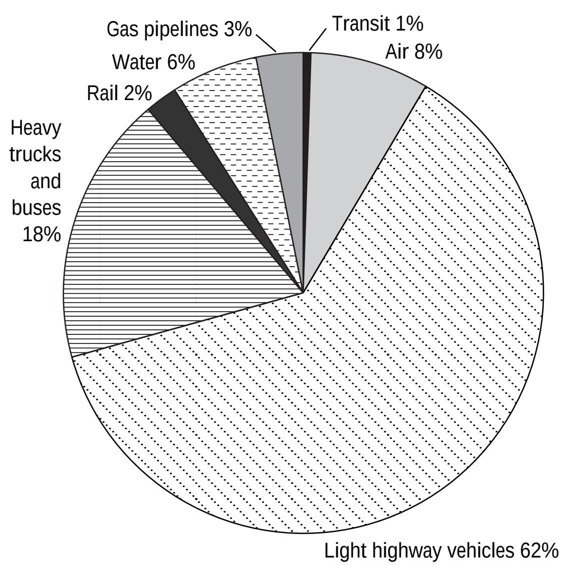
In 1997, the U.S. economy imported more oil than ever before. Yet, 25 years after the oil price shock of 1973–74, petroleum dependence is no longer a front-page news story. Oil supplies are plentiful, world oil demand is growing more slowly, and oil prices, though in 1996 nearly 70 percent higher than 1972 levels (in constant dollars), are much lower than the price peaks of the early 1980s. (A gallon of gasoline, in constant

Figure 4-1.
Transportation Energy Use and Highway Vehicle-Miles: 1950–96



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at http://www.bts.gov/ntda; U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996,* DOE/EIA-0384(96) (Washington, DC: 1997), table 2.1.

Figure 4-2.
Transportation Energy Use by Mode: 1996

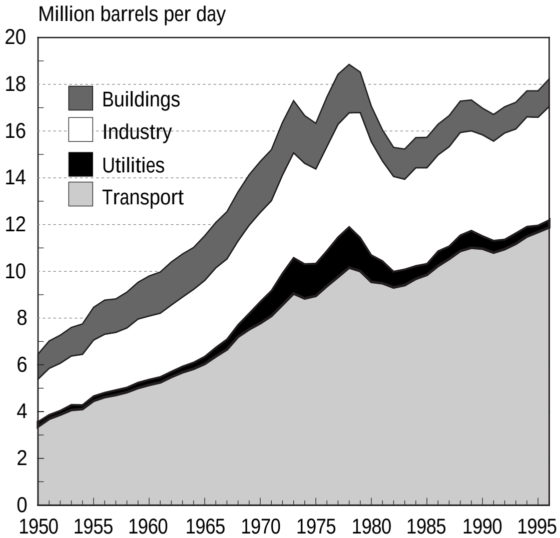


SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at http://www.bts.gov/ntda, table 4-10.

dollars, costs no more today than in 1970.) Members of the Organization of Petroleum Exporting Countries (OPEC), however, still supply more than 40 percent of the world's oil and own the majority of the world's oil resources. As U.S. oil production declines and consumption rises, dependence on OPEC will most likely increase. This section describes the energy and economic aspects of oil dependence and some of its implications. There are geopolitical implications as well, which are topics of heated debate but are outside the scope of this report (see, e.g., *Harvard International Review* 1997).

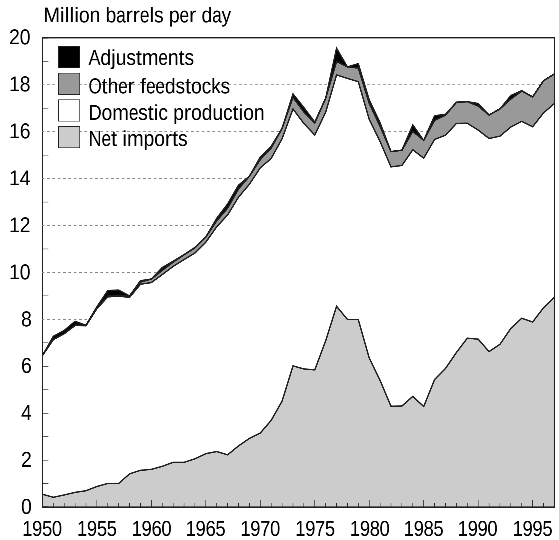
U.S. dependence on imported petroleum is more than ever a result of transportation's reliance on oil. Transportation is the only sector of the economy that consumes significantly more petroleum today than in 1973 (see figure 4-3). Use of petroleum in electricity generation decreased from 3.1 quadrillion Btu (quads) in 1972 to 0.7 quads in 1996 (USDOE EIA 1997a, table 8.5). Over the same period, the residential and

Figure 4-3.
Transportation's Share in U.S. Petroleum Use: 1950–96



SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC: 1997), table 5.12.

Figure 4-4.
U.S. Petroleum Imports, Domestic Production, and Other Feedstocks: 1950–96



NOTE: Adjustments include crude oil losses and changes in stocks.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC: 1997), table 5.1.

commercial buildings sectors cut petroleum use in half, from 4.4 quads to 2.2 quads, while industrial sector petroleum use remained stable: 9.1 quads in both 1973 and 1996. In contrast, transportation's petroleum use increased by one-third over the same period, from 17.8 quads to 23.7 quads. In 1973, transportation accounted for roughly half of U.S. petroleum demand; today it comprises almost two-thirds.

In 1997, the United States imported 8.95 mmbd of crude oil and petroleum products.[1] This exceeds the previous record high for imports of 8.56 million barrels per day (mmbd) (see figure 4-4). U.S. petroleum imports nearly tripled between 1967 and 1973, from about 2 mmbd to 6 mmbd. A combination of declining domestic production, rapidly growing demand, and low prices made imported oil attractive. The OPEC oil embargo, which began in the fourth quarter of 1973, and the consequent higher oil prices and economic recessions in 1974 and 1975, temporarily held oil imports in check. With economic recovery, oil imports shot up in 1976 and 1977, reaching a high of 46.5 percent of total consumption in 1977. That record stood for two decades as a second round of oil price shocks and economic recessions in 1979 and 1980 depressed demand.

Oil prices in 1981 were almost five times their 1972 level (in constant dollars), depressing demand and stimulating domestic supply. Imports remained low for several years, as OPEC continued to cut back its production to sustain the higher price levels. Responding to shrinking market share and revenues, OPEC members abandoned the defense of higher oil prices in 1986. The resulting increase in oil supply caused prices to plummet and U.S. oil

[1] The numbers reported here are net imports, which equal total imports minus total exports. The United States exports just under 1 mmbd of petroleum.

imports to rise once again. Since 1986, U.S. oil imports have continued to increase, temporarily interrupted by the oil price jump and recession associated with the Persian Gulf War in 1990–91 and by a substantial drawdown of domestic petroleum stocks in 1995.

Whether a high level of oil imports poses serious strategic and economic problems for the United States depends on a number of factors, some of which can be readily measured, while others cannot. The potential for oil dependence to harm the U.S. economy hinges on the ability of the OPEC cartel to raise world oil prices above competitive market levels. According to economic theory, the *potential* market power of a cartel, such as OPEC, is a function of its share of the market and the ability of both oil users and other suppliers to respond to price increases. The more of the world's oil needs OPEC supplies, the greater its ability to influence prices, other things being equal. At the same time, the greater the ability of oil consumers to reduce consumption when prices increase, whether through efficiency improvements, substitution of alternative energy sources, or cutting back on activities that use oil, the less market power the cartel can wield. Also, the more easily non-OPEC oil producers can expand production when prices rise, the smaller the cartel's market influence. Finally, in a dynamic market, the faster the demand for oil grows, the greater the impact of a reduction in supply.

A key complicating factor is the very large difference between the oil market's short-run and long-run ability to respond to sudden changes in supply and demand. Because it takes time to find and develop new oil supplies, and even longer to turn over transportation vehicle stock and other oil-using capital equipment, a rapid reduction in supply will produce a much larger change in price than the same reduction phased in over several years. This means that sudden supply shocks, whether intentional or unintentional, can have a huge impact on oil prices. The doubling of world oil prices in 1973–74 and again in 1979–80 were associated with reductions of world oil supplies on the order of 5 percent (Greene et al 1998).

Several factors determine the impacts of price shocks on oil consuming economies: 1) the economic significance of oil (e.g., the oil cost share of GDP), 2) the ability to substitute other factors for oil quickly and cheaply (best indicated by the price elasticity of oil demand), 3) the policy response to the supply shock (e.g., tightening or loosening of money supplies or price controls), and 4) the quantity of oil imported. The quantity of oil imported matters to the U.S. economy, because a price shock transfers wealth from oil consuming nations to oil producing nations. (This transfer is not a cost to the world economy, but a redistribution of wealth among economies. The size of the loss to an oil importing economy is directly proportional to the quantity of oil imported.) The quantity of oil imports may also have strategic implications in the case of a military conflict, since essentially all U.S. oil imports arrive by sea. About 53 percent of U.S. oil import needs, however, are now supplied by Western Hemisphere countries: 4.0 mmbd of the 7.5 mmbd of U.S. crude oil imports in 1996 came from Canada, Mexico, and Central and South America, which are relatively secure suppliers (USDOE EIA 1997d, 72).

In 1973, OPEC members supplied more than half of the world's oil needs. OPEC's market share dropped to a low of 29 percent in 1985, but rebounded to 42 percent by 1993, where it has remained through 1996. For the past few years non-OPEC producers, especially in the North Sea region, have expanded production sufficiently to supply the majority of the world's growing demand. The U.S. Department of Energy (DOE) foresees continued growth in non-

OPEC supply due to improved technology for oil discovery, development, and production (USDOE EIA 1997b, 29). Even so, the Energy Information Administration's (EIA) Reference Projection for world oil markets anticipates OPEC's share surpassing 50 percent of world production between 2010 and 2015. The technological advances that have enabled the recent increases in non-OPEC supply may also increase the price responsiveness of non-OPEC oil supply, but this has yet to be established (USDOE EIA 1997d, 61). Increased price responsiveness of non-OPEC supply would reduce the likelihood of severe oil market disruptions in the future.

Transportation sector oil demand is less "price elastic" than that of other sectors of the economy (USDOE EIA 1997d, 67), so an increase in the fraction of oil used in the transportation sector may imply a decrease in the price responsiveness of petroleum demand. Decreased price elasticity of petroleum demand would tend to increase the risk of future oil price shocks. To what extent technological gains on the supply side may offset an increased concentration of oil demand in transportation and whether advances in transportation technology may enhance the sector's ability to respond to price increases are important issues for future research.

More than 95 percent of transportation's energy comes from petroleum (USDOE EIA 1997a, table 2.1; 1997b, table 2.5). The small fraction of energy from other sources is growing, but this does not yet indicate a trend away from petroleum. As shown in last year's analysis (USDOT BTS 1997, chapter 4), far more nonpetroleum energy is used in the form of gasoline blending agents (primarily for environmental reasons) than is used by all the alternative fuel vehicles on the road.

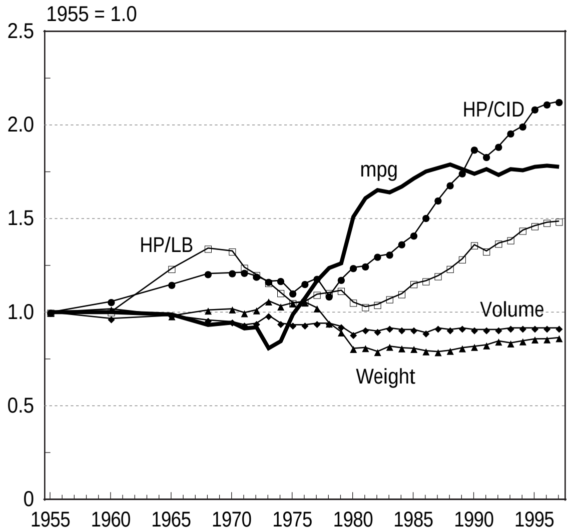
Vehicle Efficiency

Over the past quarter century, transportation energy use and CO_2 emissions increased more slowly than transportation activity because of improvements in the efficiency of energy use. From 1985 to 1995, transportation's CO_2 emissions and energy use both increased by 19 percent. Over the same period, passenger-miles traveled grew by 35 percent and ton-miles by 24 percent. As pointed out in past editions of the *Transportation Statistics Annual Report*, however, the improvement of transportation energy efficiency has slowed and may even have stopped.

Light-duty highway vehicles—passenger cars, light trucks, and motorcycles—account for almost 60 percent of transportation energy use (Davis 1997, table 2.10). Because light-duty vehicles are subject to federal automotive fuel economy standards, accurate records are kept of their fuel economy and some related characteristics (USDOT NHTSA 1997).

New passenger car fuel economy declined gradually from 1955 to 1973 and then shot upward to 26.6 miles per gallon (mpg) in 1983. It then increased gradually to 28.5 mpg in 1987, where it has remained, more or less, for the past decade (see figure 4-5). Although neither new car nor new light truck fuel economy has increased in the past decade, technological improvements to vehicles and engines have continued at a rapid pace. The ratio of horsepower to engine size (HP/CID), one indicator of the status of engine technology, has increased steadily and has approximately doubled since 1975. From 1985 to 1996, the percentage of new cars and light trucks equipped with fuel injection (versus carburetion) increased from 55 percent to 100 percent, and from 14 percent to 100 percent, respectively. The number of cars with four-valve (versus two-valve) engines increased from 1 percent to over 50 percent over the same period

Figure 4-5.
Passenger Car Fuel Economy and Related Indices 1955–97



KEY: HP/CID = ratio of horsepower to engine size; mpg = miles per gallon; HP/LB = horsepower per pound.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, "Production Weighted Data from Manufacturer's Fuel Economy Reports," data tables, 1997.

(Heavenrich and Hellman 1996, table H-3). Use of lock-up torque conversion in transmissions (a technology that reduces slippage and thereby improves energy efficiency) and front-wheel drive also increased by about 20 percent. These technologies can be used either to increase mpg or to provide increased power and weight at the same mpg. While mpg has changed little, cars and light trucks have become much more powerful and somewhat heavier. The ratio of engine horsepower to vehicle weight increased by almost 50 percent from 1985 to 1997 (see figure 4-5). At the same time, the average weight of a passenger car increased by 200 pounds, and the average weight of a light truck increased by 600 pounds (USDOT NHTSA 1997).

In effect, passenger car fuel economy has not changed significantly in the last decade, which is roughly the expected lifetime of a new automobile (Davis 1997, table 3.5). It would be reasonable to expect, therefore, that the fleet average fuel economy improvement rate would be slowing down as the efficiency of cars on the road approaches that of new vehicles. This appears to be happening.

According to Federal Highway Administration (FHWA) estimates, the average fuel economy of all passenger cars on the road increased from 13.8 mpg in 1976 to 21.2 mpg in 1991, an average annual improvement rate of 2.9 percent per year (USDOT FHWA 1997, table VM-201A). From 1991 to 1996, FHWA estimates that mpg increased to 21.3, for an average annual rate of only 0.1 percent per year. Data from EIA's Residential Transportation Energy Consumption Survey (RTECS) are similar although not identical to the FHWA mpg estimates. Although RTECS data cover only passenger cars and light trucks domiciled at residences, this is still the vast majority of all light-duty vehicles (roughly 80 percent or more).[2]

As for new light trucks, the average fuel economy has not increased since 1982 (20.5 mpg in 1982 v. 20.4 mpg in 1997). From 1991 to 1995, FHWA estimates that the onroad fuel economy of two-axle, four-tire trucks (approximately equivalent to EPA's definition of light trucks) improved only 0.3 mpg, from 17.0 to 17.3. The clear implication is that, unless new car fuel economy begins to increase once again, we are nearing the limits of onroad fleet mpg gains.

In addition, the greater popularity of light trucks may well offset the remaining mpg gains from stock turnover. Light trucks' share of the light-duty vehicle market has grown from 10 percent in 1979 to over 40 percent today. In recent years, the greatest gains have been made by the larger four-wheel drive light trucks and

[2] As discussed in chapter 5, RTECS has been discontinued due to budget reductions.

passenger vans. Four-wheel drive large pickups and four-wheel drive sport utility vehicles increased their combined share of the light truck market from 29 percent in 1984 to 44 percent in 1997. Passenger vans doubled their share of new light truck sales from 8 percent to 17 percent over the same period. At the same time, light truck mpg improvement has been quite modest in comparison to that of passenger cars. In 1979, the fleet average mpg for new cars was 20.3 mpg and stands at 28.6 today. New light truck mpg averaged 18.2 in 1979 and stands at only 20.4 in 1997. The combination of booming light truck sales and modest improvement in light truck mpg has restrained the overall gains in light-duty vehicle fuel economy. Had the light truck market share remained at its 1979 level, the average fuel economy of new light-duty vehicles in 1997 would have been 27.5, instead of the 24.3 actually recorded (USDOT NHTSA 1997). It should be noted that 1979 was a particularly poor year for light truck sales and that the choice of a different base year for comparison would indicate a smaller effect on light-duty vehicle mpg.

Alternative Fuels

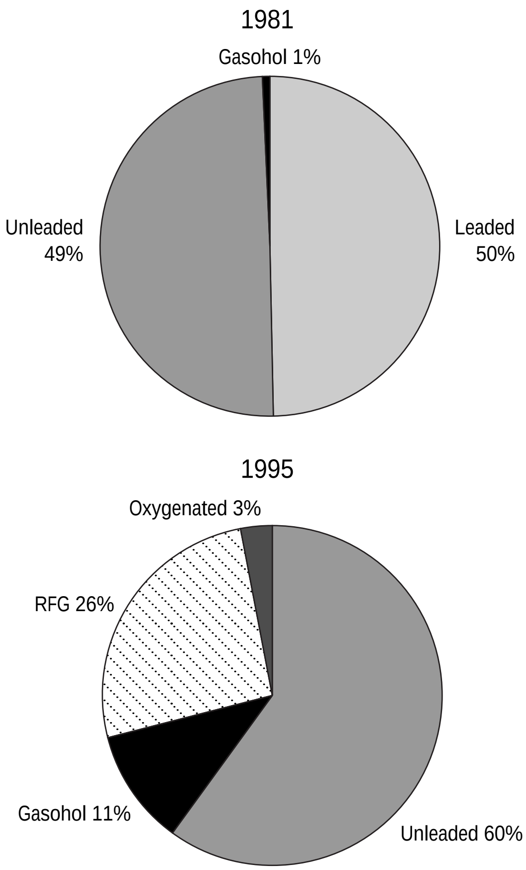
Regulating fuels to achieve environmental benefits started with the gradual elimination of lead from gasoline in the United States (Thomas 1995). The Clean Air Act of 1970 established a schedule for reducing the lead content of gasoline to lessen the amount of harmful lead in the environment. Before CAA regulations, adding 2.5 grams of lead per gallon of gasoline was typical. By 1982, the maximum amount of lead allowed in gasoline was reduced to 1.1 grams per gallon. In July 1985, the allowable lead content was reduced to 0.5 grams per gallon, and then to 0.1 grams per gallon in January 1986 (USDOE EIA OOG 1991, 12). The introduction of catalytic converters on vehicles to control emissions of hydrocarbons, carbon monoxide (CO), and nitrogen oxides (NO_X) gave further impetus to the lead phasedown program. Since the precious metal catalysts were rendered ineffective by lead, new vehicles with catalytic converters were required by law to use only unleaded gasoline. (Unleaded gasoline is defined as containing less than 0.05 grams of lead per gallon.) Leaded gasoline has now disappeared from the U.S. market (see figure 4-6) and only trace amounts remain in gasoline.

In recent years, the idea of coordinating fuel characteristics with vehicular emissions controls to maximize clean air benefits has become firmly established. Oxygen in the form of alcohols and ethers is added to gasoline to help reduce CO emissions. Ethanol, which is an oxygenate, has been blended with gasoline to create gasohol. Adding ethanol or methyl-tertiary-butyl-ether (MTBE) to gasoline has an added benefit of boosting its octane rating. Federal reformulated gasoline (RFG) standards put in place in late 1994 not only require the addition of oxygenates, but the reduction of toxic constituents such as benzene, the control of vapor pressure to reduce evaporation, and adherence to other fuel characteristics, as well.

Oxygenates, including ethanol now comprise 14 percent of the gasoline pool, up from only 1 percent in 1981 (some gasohol shown in figure 4-6 may be double counted as oxygenated gasoline). RFG, which was nonexistent in 1990, comprised 26 percent of all gasoline sold in 1995 and increased its share to 30 percent of all gasoline sold in the United States in 1996 (USDOE EIA 1997e, table 17).

The impacts of these sweeping changes in market shares on the price of fuel, however, have been relatively small. Taking the lead out of gasoline is estimated to have cost less than 1/2¢ per gallon (Thomas 1995). The observed price differential, however, has varied from 2¢ to 11¢ per gallon. RFG costs about 4¢ more per gallon

Figure 4-6.
U.S. Motor Gasoline: 1981 and 1995



SOURCES:
For U.S. production and imports of reformulated gasoline (RFG) and oxygenated gasoline, U.S. Department of Energy, Energy Information Administration, *Petroleum Supply Annual* (Washington, DC: 1993–1996 editions), tables 17 and 20.

For U.S. supply of leaded and unleaded gasoline, U.S. Department of Energy, Energy Information Administration, Office of Oil and Gas, *The Motor Gasoline Industry: Past, Present, and Future*, DOE/EIA-0539 (Washington, DC: January 1991), table 5.

For U.S. highway gasoline use and gasohol sales, U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics Summary to 1995* (Washington, DC: 1995), tables MF-226 and MF-233GLA.

to produce and deliver to the consumer than conventional gasoline (USDOE EIA 1997d, 21). RFG is typically sold in large cities with ozone nonattainment problems. National average prices for RFG tend to be about 6¢ per gallon higher than conventional gasoline of the same grade. This compares with a typical seasonal variation in the price of gasoline of about 5¢ per gallon.

Changes in the composition of gasoline have had a far greater impact on the nature of transportation energy use than all alternative fuel use to date. From 1992 to 1997, use of alternative and replacement fuels in the U.S. transportation sector almost doubled, from 2.1 billion to a little more than 4.0 billion gasoline equivalent gallons (see table 4-1).[3] Of the 2 billion gallon increase, 1.86 billion is attributable to increased use of MTBE, other ethers, and ethanol as oxygenates in gasoline. Only 11 million gallons are attributed to alternative fuel use in alternative fuel vehicles. Vehicles using liquefied petroleum gas and compressed natural gas remain by far the most common types of alternative fuel vehicles on U.S. highways.

GREENHOUSE GASES: THE CHALLENGE OF KYOTO

Growing concern about increasing concentrations of greenhouse gases in the atmosphere and the resultant potential for global climate changes (such as increasing temperatures, loss of coastal land to rising oceans, and greater frequency of violent weather) has led to an international agreement to reduce emissions of six GHGs. In December 1997, representatives of 159 countries met in Kyoto, Japan, on the Protocol to the United Nations Framework Convention on Climate Change, a convention resulting from the 1992 Earth Summit in Rio de Janeiro. In Kyoto, the United States and other industrialized countries agreed to binding commitments to reduce GHG emissions. Many issues remain contentious, and

[3] A gasoline equivalent gallon is defined as the lower heating value energy content of one gallon of gasoline. Lower heating value equals the Btus released by combustion, excluding the energy released by condensing water vapor produced in combustion.

Table 4-1.
Estimated U.S. Consumption of Alternative and Replacement Fuels: 1992–97
(Thousand gasoline-equivalent gallons)

Fuel	1992	1993	1994	1995	1996	1997[1]
Total fuel consumption[2]	134,230,631	135,912,964	139,847,642	143,019,659	145,634,659	148,289,767
Total alternative and replacement fuels	2,105,631	3,122,534	3,145,852	3,879,407	3,707,131	4,032,889
Alternative fuels						
Subtotal	229,631	293,334	281,152	277,507	297,231	321,389
Liquefied petroleum gas (LPG)	208,142	264,655	248,467	232,701	239,158	244,612
Compressed natural gas (CNG)	16,823	21,603	24,160	35,182	46,923	63,258
Liquefied natural gas (LNG)	585	1,901	2,345	2,759	3,247	4,567
Methanol, 85%[3] (M85)	1,069	1,593	2,340	2,887	3,390	3,625
Methanol, 100% (M100)	2,547	3,166	3,190	2,150	347	347
Ethanol, 85%[3] (E85)	21	48	80	190	694	1,416
Ethanol, 95%[3] (E95)	85	80	140	995	2,699	2,628
Electricity	359	288	430	663	773	936
Replacement fuels (oxygenates)						
Subtotal	1,876,000	2,829,200	2,954,700	3,601,900	3,409,900	3,711,500
Methyl-tertiary-butyl-ether (MTBE)[4]	1,175,000	2,069,200	2,108,800	2,691,200	2,749,700	2,923,700
Ethanol in gasohol	701,000	760,000	845,900	910,700	660,200	787,800
Traditional fuels						
Subtotal	134,001,000	135,619,630	139,566,490	142,741,750	145,334,920	147,950,950
Gasoline[5]	110,135,000	111,323,000	113,144,000	115,943,000	117,768,000	120,125,000
Diesel	23,866,000	24,296,630	26,422,490	26,798,750	27,566,920	27,825,950

[1] Estimated numbers.
[2] Total fuel consumption is the sum of alternative fuels and traditional fuels. Replacement fuels are included in gasoline consumption.
[3] The remaining portion of 85% methanol and both ethanol fuels is gasoline.
[4] Includes a very small amount of other ethers, primarily tertiary-amyl-methyl-ether (TAME) and ethyl-tertiary-butyl-ether.
[5] Gasoline consumption includes ethanol in gasohol and MTBE.

NOTES: Fuel quantities are expressed in a common base unit of gallons of gasoline-equivalent (GGE) to allow comparisons of different fuel types. GGE does not represent gasoline displacement. GGE is computed by dividing the lower heating value of the alternative fuel by the lower heating value of gasoline and multiplying this result by the alternative consumption value. Lower heating value refers to the Btu content per unit of fuel excluding the heat produced by condensation of water vapor in the fuel. Totals may not equal sum of components due to rounding.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1996*, DOE/EIA-0585(96) (Washington, DC: December 1997), table 10.

U.S. ratification of the agreement requires approval by a two-thirds majority vote of the U.S. Senate. Until the United States ratifies the protocol, it is not formally bound by its provisions.

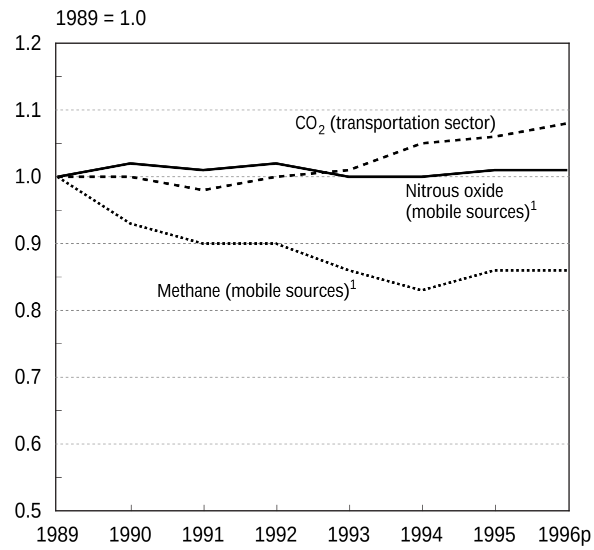
Energy use, especially the combustion of fossil fuels, is the principle source of GHG emissions from human activity (anthropogenic). For the United States, energy-related CO_2 emissions account for 84 percent of total GHG emissions (USDOE EIA 1997c, figure ES1). Methane emissions contribute another 10 percent, more than one-third of which is attributable to energy production and use. CO_2 emissions not related to energy use account for just over 1 percent of U.S. GHG emissions, and all other sources combined (including nitrous oxide—N_2O) account for less than 5 percent. Thus, it is reasonable to focus on CO_2 emissions as the predominant GHG and fossil fuel use as the predominant cause of CO_2 emissions.

Transportation accounts for about one-third of total CO_2 emissions from anthropogenic sources (USDOE EIA 1997c, 15). The growth of U.S. GHG emissions may have to be reversed if the United States is to meet the Kyoto protocol goals for the 2008 to 2012 period. Reducing transportation emissions of GHGs is not a necessary condition for reducing overall U.S. emissions. If transportation emissions continue to grow, however, it will be that much more difficult for other sectors to make up the difference.

In 1996, U.S. transportation-related GHG emissions grew 3.4 percent over 1995. This was the largest increase since 1989, the first year for which EIA provides a detailed accounting of total U.S. emissions of all types of GHGs (USDOE EIA 1997c, ix). This rate of increase is faster than the growth of energy consumption from transportation (3.2 percent) and faster than the growth of the economy (2.4 percent). Transportation, however, was not a significant factor in the accelerated growth of GHG emissions. Severe winter weather caused emissions due to residential and commercial buildings' energy use to increase by 6.3 percent and 5.5 percent, respectively. An increase in natural gas prices prompted a shift to coal for electricity generation that caused an extra 2.3 percent increase in carbon emissions over and above the 2.4 percent increase due to the growth of electricity sales.

Figure 4-7 shows how CO_2 and other transportation-related emissions of methane and N_2O have changed between 1989 and 1996. For example, in 1996, transportation's CO_2 emissions amounted to 469 million metric tons of carbon, compared with 433 million metric tons in 1989 (USDOE EIA 1997c, table 9). Transportation-related emissions of methane have remained steady over the past several years, but account for less than 1 percent of all methane emitted from anthropogenic sources (USDOE EIA 1997c, 31). Transportation-related sources produced 148,000 metric tons of N_2O in 1996, about the same as in 1989 (USDOE EIA 1997c, 41).

Figure 4-7.
Transportation-Related Greenhouse Gas Emissions Index: 1989–96



[1] Mobile sources include emissions from farm and construction equipment, in addition to transportation sources.

KEY: p = preliminary.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 1996*, DOE/EIA-0573(96) (Washington, DC: October 1997).

As discussed in the previous section, energy use has increased steadily in recent years because it is inexpensive and readily available. This growth would have to be curbed for the United States to reduce domestic GHG emissions. In this case, transportation would likely be responsible for some of the reductions, which could be achieved from improved vehicle efficiency or alternative fuels that do not contain as much carbon. As noted previously, the gains in vehicle efficiency initiated in the 1970s and 1980s appear to have run their course. If changes in vehicles and fuels are to significantly reduce growth in domestic transportation CO_2 emissions by the 2008 to 2012 period, fuel economy of new vehicles will have to start increasing quite soon to achieve substantial fleet penetration.

THE ENVIRONMENT

The many benefits of our nation's transportation system come at an environmental cost, including air and water pollution, unwanted noise, generation of solid wastes, and damage to wildlife habitat and ecosystems. *Transportation Statistics Annual Report 1996* (USDOT BTS 1996) discussed in more detail the environmental impacts of transportation. This section briefly updates trend data about transportation-related air pollution, aircraft noise, aviation-related deicing and anti-icing, leaking underground storage tanks, dredging of sediments, scrap tire disposition, and habitat impacts.

Air Pollution

Air pollution is the most visible and pervasive environmental impact of transportation, and its constituents contribute to ill health, acid deposition, smog, and stratospheric ozone depletion. Air pollutants include:

- criteria pollutants, such as CO, volatile organic compounds (VOC), nitrogen dioxide (NO_2), lead, ozone, and particulate matter of various sizes;
- chlorofluorocarbons (CFCs), which destroy the Earth's protective ozone layer; and
- toxic pollutants, also called hazardous air pollutants, such as benzene, 1,3-butadiene, formaldehyde, and acetaldehyde.

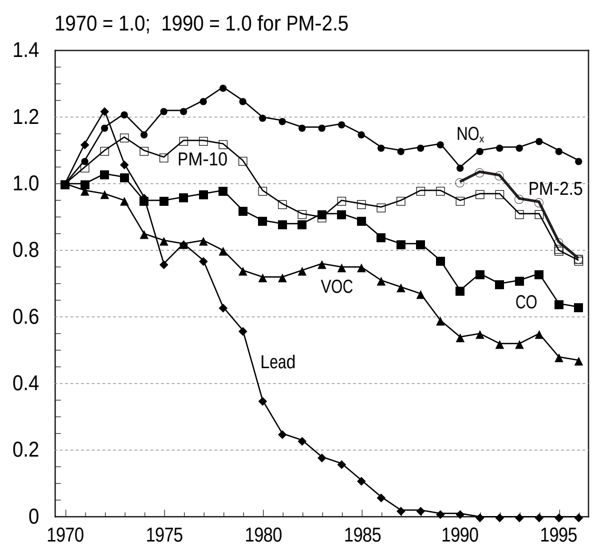
Emissions of many of these pollutants have been regulated and monitored since the advent of the CAA in 1970. Subsequent amendments to the CAA expanded regulations and tightened air quality standards, resulting in improved air quality.

Overall emissions of key air pollutants from transportation decreased between 1970 and 1996, despite an increase in vehicle-miles traveled. Most of the reduction came from light-duty passenger vehicles, which are the main source of most of these emissions. Decreases in these vehicle emissions are due primarily to tailpipe and evaporative emissions standards established by EPA, fuel economy improvements, and the ban on lead in motor vehicle fuel. Recently, EPA has focused regulatory efforts on fuel composition, in-use vehicle tailpipe emissions, and previously unregulated nonhighway vehicles in an attempt to further reduce transportation-related emissions (see USDOT BTS 1997).

EPA reports that most emissions declined in 1995 and 1996, following increases in some pollutants estimated for 1992 through 1994[4] (see figure 4-8). There were sizable reductions in estimated emissions of PM-10 and PM-2.5 (particulate emissions less than 10 microns and 2.5

[4] Emissions from transportation and other sources are estimated by EPA using a number of complex models and methodologies. Air quality, conversely, is directly measured by monitoring stations that collect and record pollutant concentrations in the ambient air.

Figure 4-8.
National Transportation Emissions Trends
Index: 1970–96



SOURCE: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Pollutant Emission Trends, 1900–1996* (Research Triangle Park, NC: 1998).

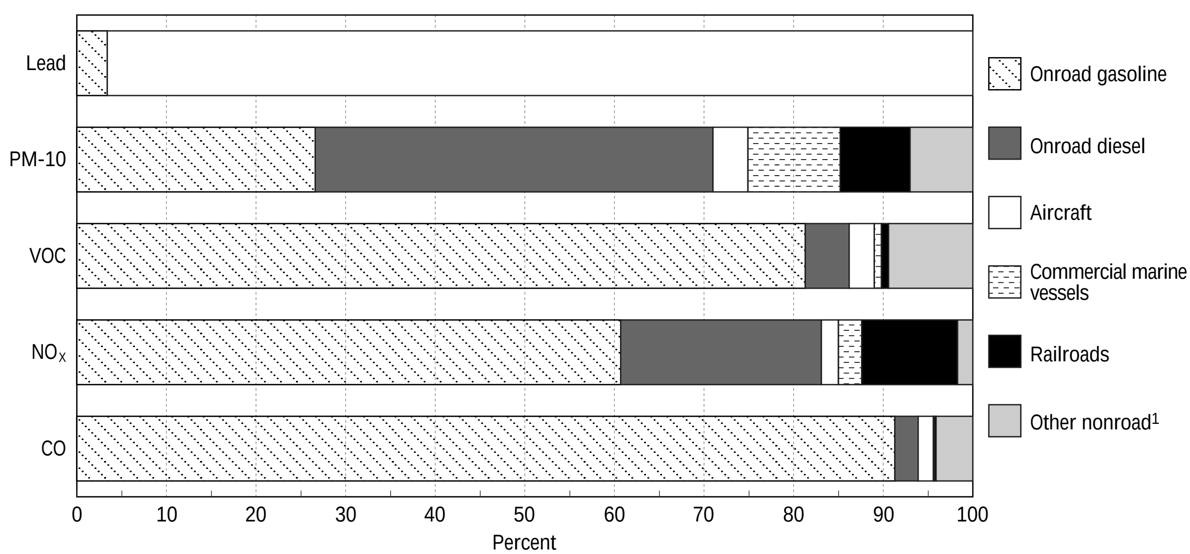
microns in size, respectively), while CO and VOC decreased only slightly. Only NO_X emissions remain above 1970 levels, decreasing moderately but still above their 1990 low point (USEPA OAQPS 1998a, A1–A29).

With the exception of lead, highway vehicles were the primary source of several key transportation-related emissions, accounting for 94 percent of CO, 83 percent of NO_X, 86 percent of VOC, and 71 percent of PM-10 emissions in 1996 (see figure 4-9) (USEPA OAQPS 1998a, A1–A29). Of these onroad emissions, gasoline-powered vehicles were responsible for most emissions, except for PM-10. Diesel-powered onroad vehicles accounted for 44 percent of all nonfugitive PM-10. Use of leaded fuel in general aviation aircraft is responsible for almost all transportation-related lead emissions (97 percent) and 14 percent of lead emissions from all sources. The Federal Aviation Administration (FAA), EPA, and the aviation industry are examining ways to reduce the release of lead. FAA has certified several general aviation aircraft engines to use alternative fuels.

▶ Air Quality Trends

Air quality is a measure of the concentration of pollutants in the atmosphere. Since 1975, air quality trends nationwide have improved considerably, according to EPA data (see figure 4-10). Lead concentrations show the greatest reduction, followed by CO. Ozone and NO_2 concentrations have dropped, but improvements since 1990 are less consistent. In 1996, national average air quality trends for most transportation-related pollutants showed a slight improvement or remained unchanged from 1995 levels. Ground-level ozone concentrations decreased, although this is mostly relative to the small upward spike in the 1995 average concentration. CO and PM-10 concentrations continued a general slow and steady decrease, while NO_2 and lead concentra-

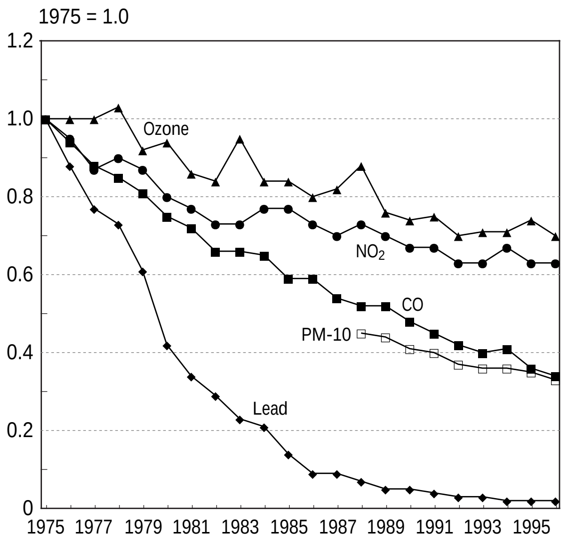
Figure 4-9.
Modal Shares of Key Pollutants from Transportation Sources: 1996



[1] Includes recreational vehicles, recreational marine vessels, and airport services vehicles. Does not include construction equipment, industrial logging equipment, and lawnmowers.

SOURCE: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Pollutant Emission Trends, 1900–1996* (Research Triangle Park, NC: 1998).

Figure 4-10.
National Air Quality Trends Index for Criteria Pollutants: 1975–96



SOURCES: U.S. Environmental Protection Agency, *National Air Quality and Emissions Trends Report, 1994* (Research Triangle Park, NC: 1995), table A-9.
______. *National Air Quality and Emissions Trends Report, 1995* (Research Triangle Park, NC: 1996), table A-9.
______. *National Air Quality and Emissions Trends Report, 1996* (Research Triangle Park, NC: 1998), table A-9.

tions remained at 1995 levels (USEPA OAQPS 1998b, 88).

The number of areas in nonattainment for ozone decreased from 68 in 1995 to 60 in 1996; for CO, from 31 to 29; for lead, from 11 to 10; and for PM-10, from 81 to 80. Consistent with previous years, Los Angeles is still the only nonattainment area for NO_2. EPA estimates that nearly 118 million people lived in areas that were in nonattainment for one or more of these transportation-related pollutants in 1996, compared with nearly 125 million in 1995 (USEPA OAQPS 1998b, 88).

In July 1997, EPA issued new National Ambient Air Quality Standards (NAAQS) for ground-level ozone and particulate matter.[5] Under the Clean Air Act, EPA is required to review and revise (as necessary) NAAQS for the six criteria pollutants every five years. After reviewing thousands of new health studies conducted since the previous standards were established, EPA decided that revisions to ozone and particulate matter standards were necessary to protect public health. EPA is also proposing a program to reduce regional haze resulting from air pollution, with final regulations expected in 1998.[6]

Costs and Benefits of the CAA: 1970 to 1990

In 1990, the U.S. Congress directed EPA to conduct a comprehensive study to evaluate the costs and benefits of the first two decades of CAA regulations. The results of EPA's study are in a 1997 report to Congress, *The Benefits and Costs of the Clean Air Act, 1970 to 1990* (USEPA OAR 1997). Although EPA and others estimated the costs of pollution abatement and control in previous studies, this is the most detailed study of the costs and benefits of all CAA regulations. The study quantifies the direct capital, operation and maintenance, abatement, regulatory, and research and development costs of CAA measures; emissions reductions; air quality improvements; visibility improvements; human health benefits in both reduced cases of illness and the corresponding monetary savings; and reduced agricultural damage.

Between 1970 and 1990, according to EPA, Americans invested about $523 billion in air pollution abatement and control. Nearly $179

[5] For ozone: 62 *Federal Register* 38652 (18 July 1997); for particulate matter: 62 *Federal Register* 38856 (18 July 1997).
[6] 62 *Federal Register* 41138 (31 July 1997).

billion (approximately 34 percent) paid for mobile source controls, while approximately $334 billion covered stationary source controls[7] (USEPA OAR 1997, A1–A31; Gillis 1997).

EPA made two very different estimates of the range of benefits arising from this spending over the 20-year period. The higher estimate (favored by EPA) found that benefits ranged from $5.6 trillion to $49.4 trillion, with the mean estimate at $22.2 trillion. This method valued each human life at $1.6 million to $8.0 million, with the mean at $4.8 million. Under an alternate method, EPA estimated the benefits would be lower, ranging from $4.8 trillion to $28.7 trillion, with a mean estimate of $14.3 trillion. The alternate method, called for by EPA's scientific advisory council for the analysis, estimated years of life lost compared with life expectancy. In doing so, EPA applied a constant cost of $293,000 per year of life lost. In either method, the benefits of clean air investments far exceeded the costs. Whether either of these estimates accurately encompasses the range of probable benefits depends in part on assumptions about the economic costs assigned to premature mortality. In fact, a report appendix notes that avoidance of premature mortality was both the largest source of benefits and the major source of quantified uncertainty in the analysis (USEPA OAR 1997, app. J, J-1). EPA notes that this is an area where further research could reduce uncertainty in future studies.

EPA estimates that actions taken under the CAA significantly decreased emissions of most criteria pollutants. In 1990, CO emissions were 50 percent lower than they would have been otherwise, lead emissions were 99 percent lower, VOC emissions were 45 percent lower, and NO_X emissions were 30 percent lower (USEPA OAR 1997, ES-2, ES-3). Regulation of mobile sources is responsible for most of the reductions in criteria pollutant emissions. Reductions from highway vehicles accounted for most of the overall reductions in CO, VOC, lead, and NO_X, as nonhighway transportation sources of these pollutants were regulated less strictly during this period.

The reductions in emissions from both transportation and nontransportation sources improved air quality in the nation. In turn, reduced exposure to criteria pollutants resulted in improved health for many Americans, prevented many thousands of premature deaths from particulate and lead exposure, and reduced cases of cardiac and respiratory symptoms and ailments (USEPA OAR 1997, 37–38).

Emissions reductions also decreased damage to natural habitats and ecosystems (e.g., wetlands, forests, and aquatic environments) and agricultural areas due to acid deposition and ozone (USEPA OAR 1997, F-9). The benefits stemming from the preservation of natural aquatic and terrestrial ecosystems currently cannot be adequately quantified, although they are likely to be significant.

Aircraft Noise

Aircraft noise first became a widely recognized problem in the United States in the mid-1960s, as the popularity and use of commercial jet aircraft rapidly increased. Congress directed FAA to begin regulating aircraft noise in the late 1960s, establishing the first federal noise standards for new-design turbojet and transport category jet aircraft. These so-called Stage 2 aircraft noise standards were subsequently applied to all newly produced planes, including those of older designs. Still, in 1974, FAA estimated that approximately

[7] Transportation and stationary source cost shares were based on the EPA data and methodology given in the *Benefits and Costs* report, as well as data provided by Thomas Gillis of EPA. Since the costs for abatement, regulations, monitoring, research, and development were not calculated separately for each source category by EPA, it was assumed that they were distributed equally between stationary and mobile sources.

7 million people were severely affected by jet aircraft noise (USDOT FAA 1989). Thus, in 1976, FAA required that all subsonic aircraft in operation (i.e., not just new aircraft) meet Stage 2 requirements by January 1, 1985.[8]

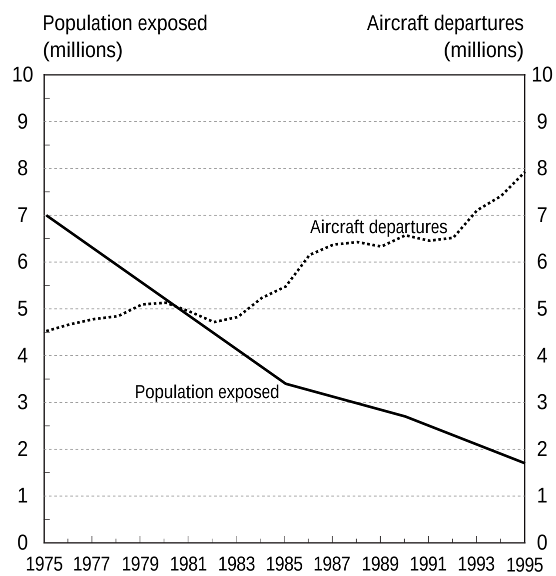
FAA implemented more stringent Stage 3 noise standards for new aircraft in 1977 and, in 1990, required a phased elimination of civil, subsonic Stage 2 turbojet airplanes over 75,000 pounds flying into or out of airports in the contiguous United States by December 31, 1999. These regulations, known as the Stage 3 transition rule, required operators to meet intermediate fleet composition goals by the end of 1994, 1996, and 1998. Operators were allowed to meet these goals by gradually reducing the number of Stage 2 aircraft in their own fleets by a given percentage or by reducing the percentage of Stage 2 aircraft within their fleet mix—both must be zero by the end of 1999. To date, the transition to Stage 3 aircraft has remained on schedule. By the end of 1996, 75.5 percent of the total fleet operating to and from U.S. airports met Stage 3 compliance requirements, up from 70.7 percent in 1995 and 66.3 percent in 1994 (USDOT FAA 1997).

Stage 2 and 3 regulations, along with airport compatibility planning,[9] have reduced the population exposed to excessive aircraft noise from airports. Recent estimates by FAA indicate that, in 1995, 1.7 million people were exposed to day-night noise levels greater than 65 decibels. Thus, exposure decreased by over 75 percent from 1975 to 1995, while commercial aircraft departures increased by over 75 percent (see figure 4-11) (USDOT FAA OEE 1997).

Airport and Aircraft Deicing and Anti-Icing

Airports and airlines deice and anti-ice runways and aircraft to ensure safe and efficient operations during wintry weather and when aircraft may encounter freezing conditions in the air. The FAA's "Clean Aircraft Concept" advisory prescribes that wings and other aircraft control surfaces be rendered free of frost, ice, or snow through use of manual methods, heated water, or

Figure 4-11.
Estimated Population Exposed to Airport Day-Night Noise Levels of 65 Decibels or More



SOURCES: Exposure estimates: U.S. Department of Transportation, Federal Aviation Administration, Office of Environment and Energy, 1997.

Departures 1975–93: U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation*, 1993, 1990, and 1980.

Departures 1994–95: U.S. Department of Transportation, Bureau of Transportation Statistics, *Airport Activity Statistics of Certificated Air Carriers: Twelve Months Ending December 31, 1995* (Washington, DC: 1996).

[8] Under Federal Aviation Regulation Part 36, aircraft sound levels are categorized by stages. Stage 1 refers to aircraft certified before FAA noise regulations. Stage 2 is the aircraft sound level needed to meet FAA 1969 noise regulations. Examples of Stage 2 aircraft include the B-727-200 and the DC 9. Stage 2 regulations are being phased out. Stage 3 refers to aircraft sound levels needed to meet FAA's more stringent 1975 noise regulations. Examples of Stage 3 aircraft include the B-737-300, the B-757, the MD-80, and the A-310.

[9] Airport compatibility planning is a noise management strategy for achieving compatibility between airport noise levels and land use in the area surrounding the airport (USDOT BTS 1996, 154).

freezing-point depressant fluids (Sills and Blakeslee 1991). The common practice is to spray or spread chemicals that lower the freezing point of water. Most of these chemicals end up in surface waters on or near airports.

Only ethylene or propylene glycol-based chemicals are certified by the Society of Automotive Engineers and approved by FAA (Mericas and Wagoner 1994). Propylene glycol costs more, while ethylene glycol is thought to have greater environmental impacts. In 1993, the U.S. Air Force prohibited the purchase of ethylene glycol-based chemicals for deicing. A Joint Service document required that propylene glycol-based chemicals be used in all but special circumstances (US Navy 1996).

The total amount of glycols released by U.S. airports is uncertain, and varies from year to year with weather, number of aircraft departures, and size and type of aircraft. A report for EPA estimated that the 17 busiest airports in the northern United States release a total of 58 million pounds of glycol per year (SAIC 1994). Another report estimated aircraft deicing product use nationwide to be 43.5 million pounds per year, based on the 1989 to 1990 season (Sills and Blakeslee 1991).

Both ethylene and propylene glycol chemicals cause environmental concerns. Although the propylene version is considered environmentally preferable, data do not suggest a clear choice. Both are highly soluble chemicals that greatly increase the biological oxygen demand (BOD) of receiving waters, but propylene exerts a higher BOD. Both can biodegrade rapidly, consuming oxygen and threatening oxygen-dependent aquatic life. Both contain additives; ethylene glycol-based deicers may also contain contaminants (SAIC 1994). Ethylene glycol is acutely toxic to mammals at relatively low concentrations. Glycols are not known to be carcinogenic, but some formulations of ethylene glycol are contaminated with trace amounts of 1,4-dioxane, an animal carcinogen (Sills and Blakeslee 1991).

Half or more of the glycols sprayed on aircraft typically fall to the ground where they may enter the stormwater drain system and mingle with other substances, be separately collected, seep through pavement into the ground, and/or mix with snow moved off pavement. The rest is retained on aircraft or dispersed into the air. At takeoff, anti-icing fluids are sheared off onto the runway area. Depending on how the airport is regulated, the stormwater containing glycols may be treated before release into surface waters. At airports with special deicing collection systems, the chemicals may be treated before release or diverted to a recycling system and processed for reuse elsewhere. There is no aggregated information on how U.S. airports handle this chemical runoff.

Environmental impacts may be mitigated through the location of deicing operations, choice of chemicals, application methods, and improved collection systems. An FAA advisory on standards and specifications for aircraft deicing facility design (mandatory for airport projects receiving federal grant assistance) recommends drainage and collection systems that isolate chemicals from the airport's central drainage system and allow deicing in gate areas or at centralized or remote facilities (USDOT FAA 1993). FAA notes that facilities close to runways can reduce the time between deicing and takeoff, thus improving safety and decreasing the amount of fluids used.

Denver International Airport has one of the most comprehensive deicing systems in the country, and uses only propylene glycol. After limited deicing at the gate area, aircraft go to one of three remote pads for deicing just prior to takeoff. Glycol runoff drains into holding ponds, and is released in allowable amounts to a local treatment works. The higher concentrated remote pad runoff is collected for processing. Yet, officials estimate that only about 60 percent of the used glycol is collected. A $2.8 million interceptor system to capture solution dripping from taxiing aircraft was installed last year, and more improvements are being sought.

Large computerized structures (or gantry systems) with numerous nozzles may reduce glycol consumption by passing over stationary aircraft and spraying specific amounts of deicer over particular areas with little waste material (USEPA OECA 1995). Some of the gantries may also have collection systems. United Parcel Service installed the system at its Louisville Airport facility about 10 years ago, but stopped using it 3 years ago because heavy, wet snow there interfered with effective operations.

Research on approaches to reduce environmental impacts include application procedures that reduce glycol consumption, and alternative chemicals and technologies. Currently, alternatives for deicing runways are more readily available than those for deicing aircraft. Technologies for deicing are now being tested. For example, DOE is funding a demonstration of a mobile unit with adjustable horizontal boom arms through which an aircraft can taxi and receive, from two separate nozzles, heated compressed air for deicing and precise amounts of glycol for anti-icing. An FAA-approved system—installed at Buffalo, New York, and Rhinelander, Wisconsin, airports—uses infrared heat to deice an aircraft as it passes through an open-ended hanger.

Leaking Underground Storage Tanks

Leaking underground storage tanks (USTs), especially those at retail gas stations, are one of the most common sources of groundwater contamination (USEPA OUST 1997b). Congress recognized the problem of leaking USTs over 10 years ago, and in September 1988 issued new standards for both new and existing USTs. These standards require newly installed USTs to be constructed of fiberglass-reinforced plastic or steel equipped with a noncorrosive lining or other corrosion protection, and to have adequate protection against spills and overflows, such as catchment basins and automatic shutoff devices or overfill alarms. Tanks that preexisted the standards must be closed, at least temporarily, if they are not upgraded or replaced by December 22, 1998.

Data compiled by the EPA Office of Underground Storage Tanks suggest that progress is being made in reducing leaking USTs. Although the number of newly confirmed UST releases increased from nearly 14,000 in 1996 to over 24,000 in 1997, the 1997 number is still fewer than the newly confirmed releases for all monitored years prior to 1996. Also, the number of cleanup efforts initiated during the year increased from 14,000 to nearly 40,000, and the number of cleanups completed during the year increased from about 21,000 to almost 26,000. As of November 1997, 163,476 leaking tank releases had not been cleaned up, the lowest number since 1994 (USEPA OUST 1997a).

Contaminated Sediment from Dredging Operations

Most ports and harbors need periodic dredging to maintain adequate depths for large ships used in world trade. The dredging, and resulting need to dispose of dredged materials, has resulted in environmental problems and conflicts, as is discussed in more detail in *Transportation Statistics Annual Report 1997*.

Dredging of sediment is carried out by the U.S. Army Corps of Engineers and U.S. port authorities. Ports spent $142 million on dredging in 1996, and between 1992 and 1996, dredging averaged 9 percent of total port capital expenditures (USDOT MARAD 1997). For 1992 through 1996, the Corps dredged an average of

265 million cubic yards per year of sediment in ports and harbors, for an annual average cost of $515 million.[10] The most costly dredging involves sediment contaminated with heavy metals or other pollutants. This contaminated sediment constitutes an estimated 5 to 10 percent (by volume) of all sediment dredged nationally each year, although the proportion varies widely by region (NRC Marine Board 1997).

In 1997, EPA published a preliminary assessment of the national incidence and severity of sediment contamination (USEPA OST 1997). EPA found that 96 watersheds in the country have areas of potential concern for sediment contamination. These areas are clustered in coastal and inland territory primarily east of the Mississippi River and in California and Washington. Limitations in available data and evaluation tools narrowed the scope of EPA's analysis. Hence, the data are not sufficient to determine the extent of contamination on a national scale. EPA considers the study output analogous to a screening assessment, not a confirmation of sediment that requires special management. The agency recommends further investigation and assessment of contaminated sediment. EPA is also conducting a contaminated sediment management study (due in 1998).

Approaches and technologies that would reduce the costs of managing existing contaminated marine sediment could improve the benefits of dredging. A 1997 National Research Council report rated a range of technologies for feasibility, effectiveness, practicality, and cost of managing contaminated marine sediment on an interim or long-term basis (NRC Marine Board 1997). No single approach emerged—four had high scores and each had one low or moderate ranking.

NRC also found a need for decisionmaking improvements, such as greater use of risk, cost-benefit, and decision analysis, and simplification of the applicable regulatory framework. Several agencies (at the federal, state, and local level) are involved at various stages of decisionmaking and implementation.[11] The agencies now work together as the National Dredge Team and seven Regional Dredge Teams as the result of a 1994 interagency report to the Secretary of Transportation (see USDOT BTS 1997).

Trends in Scrap Tire Disposition

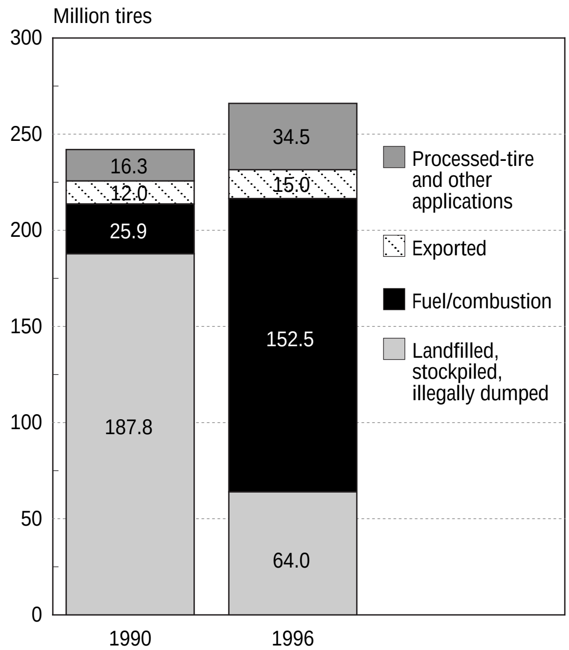
Scrap tires are a major source of solid waste from both highway and nonhighway transportation. Tire replacement is a part of regular vehicle maintenance; several sets of tires may be used and discarded during a vehicle's lifetime. Approximately 250 million scrap tires are generated annually in this country, many of which are disposed in landfills, scrap tire stockpiles, or illegally dumped. Advances in technology and applications have provided important markets for scrap tires over the past several years, greatly reducing the number of tires disposed.

EPA and the Scrap Tire Management Council estimate that the number of scrap tires stockpiled, landfilled, and dumped annually may have fallen by as much as two-thirds, while the annual number of scrap tires generated increased 10 percent (see figure 4-12) (STMC 1997, 3; USEPA SWER 1991). Scrap tire disposal decreased primarily because of a dramatic increase in their use as tire-derived fuel, currently the single largest market for these tires. From 1990 to 1996, the number of tires used as fuel increased nearly five-fold, reaching more than 150 million (STMC 1997, 3). Nonfuel markets for processed and whole tires consumed 34.5 million scrap tires in

[10] Port and Corps expenditures on dredging cannot be combined because data sources and methodologies differ.

[11] Prime actors are EPA, the Army Corps of Engineers, and the National Oceanic and Atmospheric Administration.

Figure 4-12.
Comparison of U.S. Scrap Tire Disposition: 1990 and 1996



SOURCES: 1996 data—Scrap Tire Management Council, *Scrap Tire Use/ Disposal Study: 1996 Update* (Washington, DC: 1997). 1990 data—U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Summary of Markets for Scrap Tires* (Washington, DC: 1991).

1996, twice the 1990 level. These markets include ground rubber applications, such as asphalt products, new tires, bound rubber products, and athletic surfaces; civil engineering applications, such as fill material, road bed material, and aggregate; and other applications such as artificial reefs, playground equipment, and crash barriers. Export of scrap tires has increased more modestly since 1990, from 12 million tires in 1990 to 15 million in 1996 (STMC 1997, 3).

Federal-Aid Highway Land Use and Wetlands

The most obvious land-use impact of transportation is the direct loss and degradation of natural habitats from constructing and expanding infrastructure such as roads, airports, rail lines, and ports. Many types of habitats are affected, and damage to and loss of wetland habitats are of interest because of the many benefits they provide humans and animal species, their relative fragility, and the magnitude of historical wetlands losses.

A recent EPA-sponsored study examined the impacts of the Federal-Aid Highway Program (FAHP) on wetland losses between the mid-1950s and 1980. During this period, the FAHP was very active and fewer environmental controls regulating road construction were in place compared with today. The study concluded that FAHP road construction potentially contributed to the loss of approximately 310,000 to 570,000 acres of wetlands between 1955 and 1980. This amounts to approximately 3 to 5 percent of the net wetlands acreage lost during this time. The study estimated the replacement cost for these wetlands at roughly $153 million to $6 billion (Apogee 1997). The direct impacts of rights-of-way affected approximately 184,000 to 449,000 acres. In addition, roughly 123,000 acres were lost due to agricultural draining facilitated by roadway ditches in the Prairie Pothole region, which includes most of North Dakota, roughly half of Minnesota and South Dakota, and about one-third of Montana.

The study has limitations, though. First, the wetlands losses are only rough estimates and replacement costs are orders-of-magnitude. Second, the study includes only road impacts, and the FAHP roads covered by the study constitute only one-quarter of the linear roadway mileage in the United States—non-FAHP roads include all rural minor collectors and urban and rural local roads. Finally, the study did not include many indirect impacts on wetlands, such as habitat fragmentation and alteration of hydrology. Nor did it estimate wetlands filled or affected by urban development stemming from FAHB activity.

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